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Assessment of the mechanism of fracture propagation of soft rock coastal cliffs by using non-local constitutive models

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The assessment of susceptibility to failure of soft rock coastal cliffs, along with the associated failure mechanism, is not a simple task. Equilibrium conditions depend on the combination of several factors such as structural setting, rock mechanical strength, weathering processes, the hydro-mechanical action of sea waves, the variation of the rock cliff geometry, to mention some of the most important ones. From a geomechanical perspective, the brittle - strain softening behaviour of the rocks plays a key role in the onset and propagation of failure (Ciantia & Castellanza 2015). In particular, the rapid strength reduction occurring after peak under mechanical loading leading to localised deformations within shear fractures is detrimental for rock cliffs. Taking rock brittleness into account in numerical simulations under the framework of continuum mechanics is not straightforward, due to the problems related to a strong dependence of the numerical results from the adopted mesh when strain-softening laws are implemented (Vermeer and Brinkgreve 1994). Nowadays, several regularization techniques are available to control the size of the localised region and prevent the mesh dependence. Within regularization techniques, the nonlocal integral type solution has the advantage of not changing the field equations which facilitates numerical implementation. In this approach, the chosen nonlocal variables are valuated from spatial averages of the field variables in a neighbourhood, and the constitutive model is updated by replacing a local variable with its nonlocal counterpart. Consequently, the constitutive response of a Gauss point is influenced by all the integration points within a neighbourhood, with the size determined through a characteristic length (Bažant and Jirásek 2002). This contribution addresses the problem of the stability of an ideal 2-D plane strain coastal cliff, 20-m high, by means of the use of a non-local constitutive model implemented in a commercial finite element code (Mánica et al. 2018). The numerical results show insights into the evolution of the strain field and the process of slip surface/fracture propagation in the rock cliff as well as highlight the importance of regularising the finite element solution in the presence of brittle materials.